

Investigations on frequency selective characteristics of a dielectric slab

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Abstract . In microwave frequency region, electromagnetic waves of different frequencies are propagated through a certain distance in free space and then incident normally on the surface of a finite three dimensional dielectric slab. The software "ANSOFT" in "SILICON GRAPHICS COMPUTER" then investigates the characteristics of the transmitted waves. The software utilises the finite element method. The propagation of an electromagnetic pulse through a finite three dimensional dielectric slab has already been investigated [1]. In that paper reflection characteristics of the electromagnetic wave when incident on a dielectric slab has been analysed in the frequency domain with the help of Finite Difference Time Domain method. Now in this paper transmission characteristics of the electromagnetic wave have been analysed with the help of HFSS software from ANSOFT keeping all the dimensions and conditions same as [1]. Studying the reflection and transmission characteristics of the electromagnetic waves, an idea about the frequency selective property of the dielectric slab can be obtained.

Keywords . Frequency selection, dielectric slab.

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1. Formulation of the problem and excitation

The problem solution method using High Frequency Structure Simulator requires the problem geometry to be drawn with proper dimension, using an in built 3-D solid modeller. Next

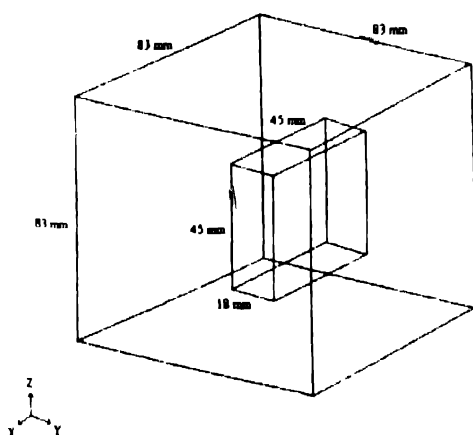


Figure 1. Problem geometry.

the material properties are specified. HFSS can analyse the fields in a finite volume of the computational domain. In solving the problem of unbounded nature, therefore, the problem space must be enclosed by an absorbing boundary which is specified as radiation surface where incident fields at that radiation boundary is radiated into background so that the reflected field does not enter into the solution space. Different boundaries within the solution space can be specified as Dirichlet Neuman or impedance boundary conditions. In our case, only perfect magnetic boundary (Dirichlet) has been assumed. The excitation can be given through ports or by incident fields. Incident fields have been used here. The solution produced by the HFSS can be viewed through a post processor interface. Various field quantities can be plotted as far field or field at a distance.

Here, we have considered a volume of 83 mm × 83 mm × 83 mm as free space. We have placed a dielectric slab as shown in Figure 1. Dimensions of the dielectric slab in x, y, z directions are 45 mm, 18 mm and 45 mm. Relative

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permittivity of the dielectric slab is 4.0. The electromagnetic wave is given by

$$E = E_0 \cdot e^{-k_0 k r}$$

where for k vector :

$$X = 0$$

$$Y = 1$$

$$Z = 0$$

and for E_0 vector :

$$x = 0 \text{ v/m}$$

$$y = 0 \text{ v/m}$$

$$z = 1 \text{ v/m}$$

That is $E = 1 \cdot e^{jk}$

Now this electromagnetic wave is incident on the dielectric slab. We have investigated the transmitted electric field at a distance of 62.5 mm in y direction from the origin in the frequency range of 0.5 GHz to 5.5 GHz with an interval of 0.2 GHz. A sample plot is shown in Figure 2.

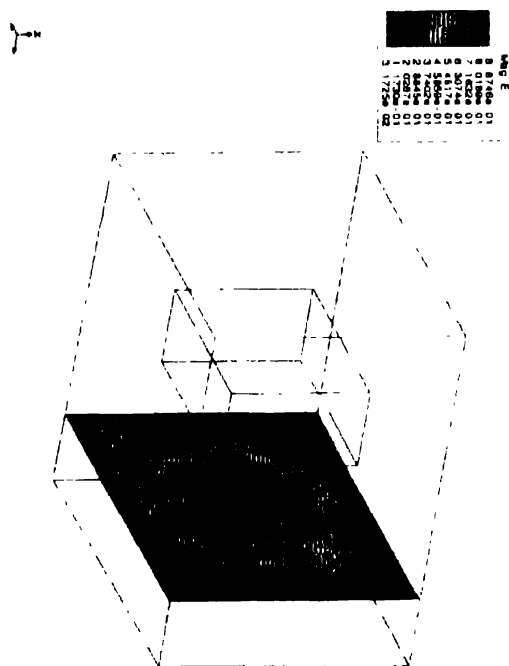


Figure 2. Electric field distribution at the frequency of 3.1 GHz

After that at a particular point ($x = 41.5$ mm, $y = 62.5$ mm, $z = 41.5$ mm from the origin), the transmitted electric field at different frequencies are noted and then normalized transmitted electric field vs frequency has been plotted in Figure 3. Normalized reflected electric field vs frequency (frequency range 0.5 to 5.5 GHz) has also been plotted in

Figure 4. The data have been obtained with the help of three dimensional F.D.T.D. method [1,2].

2. Observation

From the normalized transmitted electric field vs frequency plot (Figure 3) it is observed that transmission is minimum in the frequency range of 1 GHz to 2 GHz and transmission

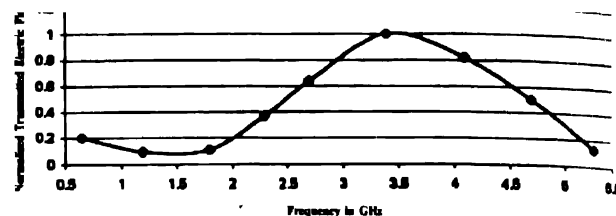


Figure 3. Normalized transmitted electric field vs frequency

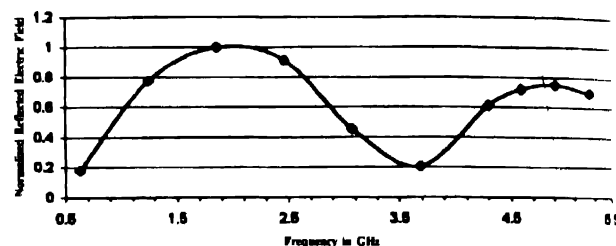


Figure 4. Normalized reflected electric field vs frequency

is maximum in the frequency range of 3 GHz to 4 GHz. It is also observed from the normalized reflected electric field vs frequency plot (Figure 4) that the reflection is minimum in the frequency range of 3 GHz to 4 GHz and reflection is maximum in the frequency range of 1.3 GHz to 2.5 GHz

3. Conclusions

Electromagnetic wave with frequency range of 3 GHz to 4 GHz can be transmitted well through the dielectric slab of the above mentioned dimensions with permittivity 4 and the electromagnetic wave with frequency range of 1.3 GHz to 2 GHz can be reflected well from the surface of the same dielectric slab. This frequency selective property of a dielectric material can be utilised in the field of satellite communication.

References

- [1] P P Sarkar and S K Choudhury *Proc. INCURSI* p 36 (1999)
- [2] R J Luebbers, K S Kunz and K A Chamberlin *IEEE Trans on Education* 33 60 (1990)